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# Topology optimization of antennas and resonators

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**Abstract**

The research presented here consists of a novel extension to the topology optimization method, that allows for systematic design of 3D metalic/dielectric devices for microwave applications. The work is a natural continuation of the 2D design formulation presented in [1] which again is motivated by the 3D antenna design from [2] and the dielectric antenna designs presented in [3] and [4]. However, it was found that modifications to the 2D design formulation from [1] were needed, both due to the presence of a plentitude of local minima in the 3D setting, but also due to issues with the design parameterization for certain antenna optimization problems. In those cases it was not possible to find a monotonous interpolation and hence we resort to a heuristic discrete scheme based on filtering and gradient evaluation for discrete variable values.

The motivation for the work originates from the ever increasing usage of small hand-held, or autonomous, electrical devices such as hearing aids, medical implants and communication devices. These devices all require antennas for communication as well as a power supply, usually a battery. Since more and more functionality is incorporated into these devices, standard antenna designs are becoming less and less usable and the requirements to the batteries are increasing. The power supply issue took a new turn in 2007, where a MIT group lead by Prof. M.Soljacic demonstrated that one could obtain efficient mid-range wireless energy transfer (WiTricity) using magnetically resonant coupled copper coils. Common for the design of antennas and devices for WiTricity are that they consist of an elaborate spatial distribution of a conductor, e.g. copper, in a dielectric background, e.g air. This makes the design of such devices an obvious candidate for the topology optimization method.

The proposed design scheme is implemented in a fully parallel C++ FE/topology optimization code, and is demonstrated on the design of 3D resonators for energy harvesting from radio frequency signals as well as the design of electrically small antenna systems.

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